Photometric Observations of Solar Irradiance Variability from SFO

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Data Description

CFDT=Cartesian Full-Disk Telescope

Daily observations (digital images) continue using CFDT1 (since 1986) and CFDT2 (since 1992).

Observations obtained on about 60% of days.

Photometric indices available on request.

Data Description, Cont'd.

- Basic Observing Technique

- Linear photodiode array is oriented N-S
- Image is scanned using Earth's rotation
- Sky transparency is recorded every line
- Original idea from Gordon Hurford passed on by Hugh Hudson at WARTS workshop(NASA SP-310)

Image Size & Scale

CFDT1

Size: 512 x 512 pixels
Scale: 5.12 arc-sec/px

CFDT2

Size: 1024 x 1024 pixels
Scale: 2.5 arc-sec/px

Wavelengths (BP)

CFDT1

673.2 (10) nm

473.2 (10) nm

393.4 (1.0) nm

CFDT2

673.2 (10) nm

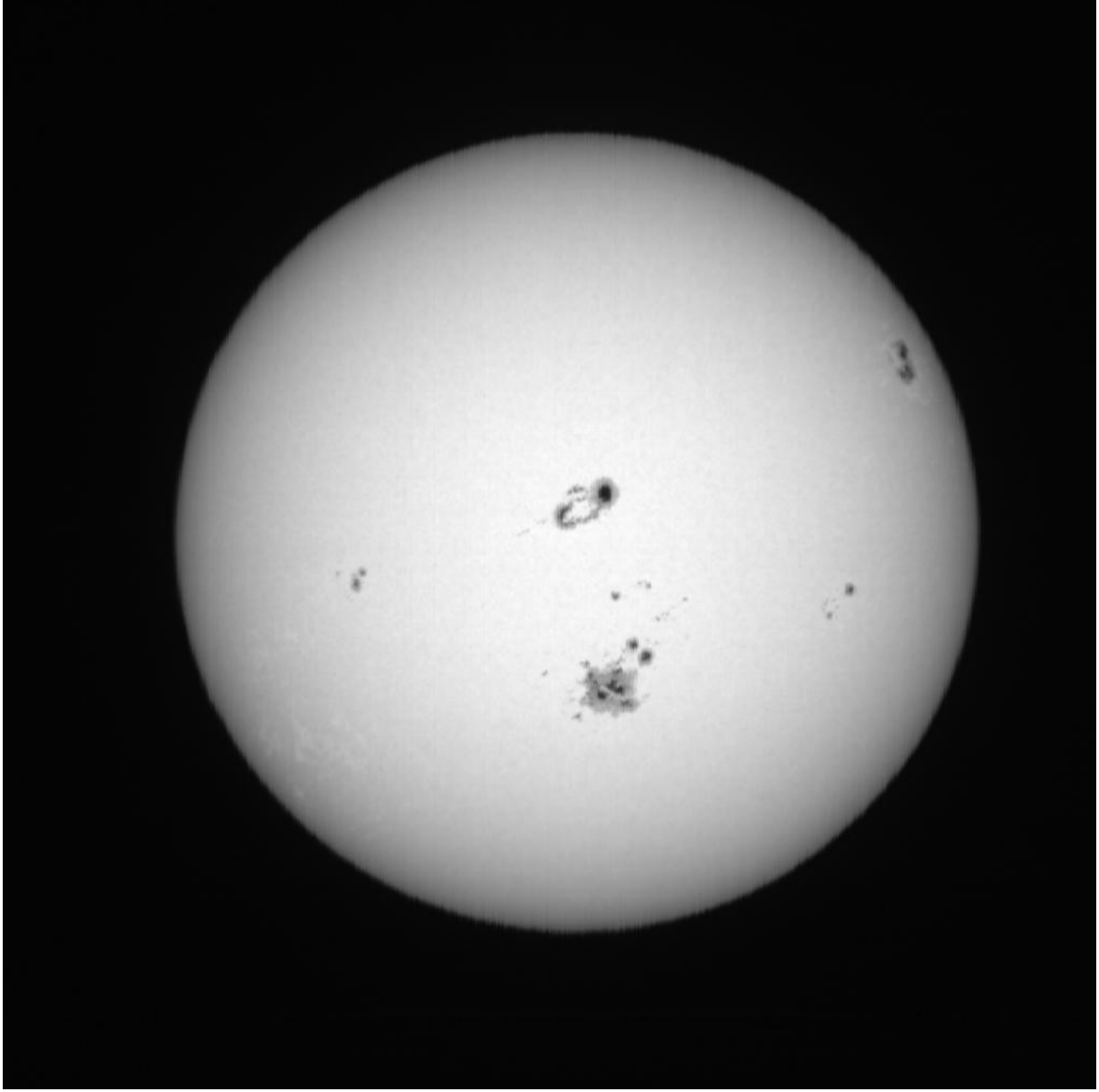
473.2 (10) nm

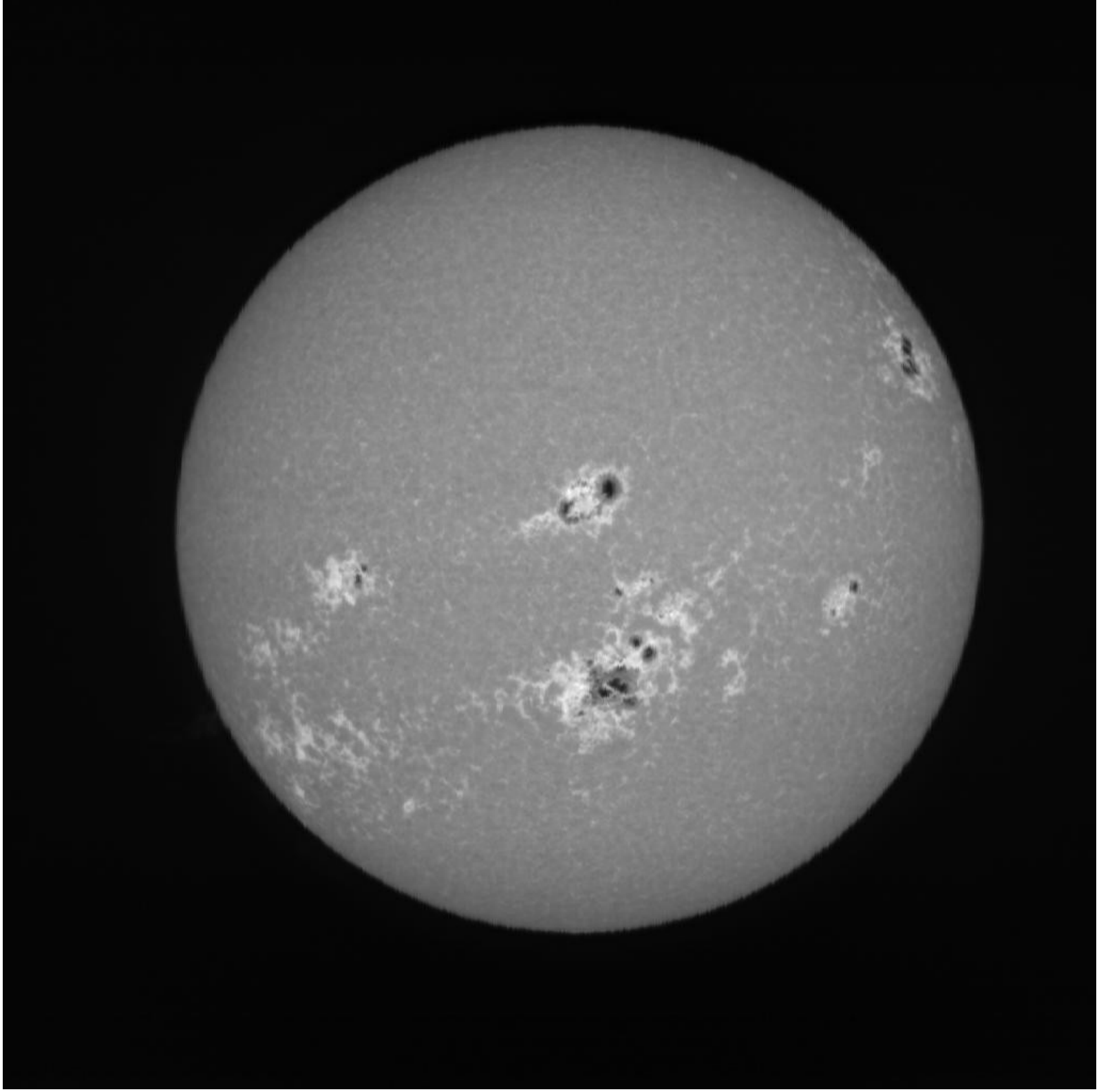
393.4 (1.0) nm

393.4 (0.3) nm

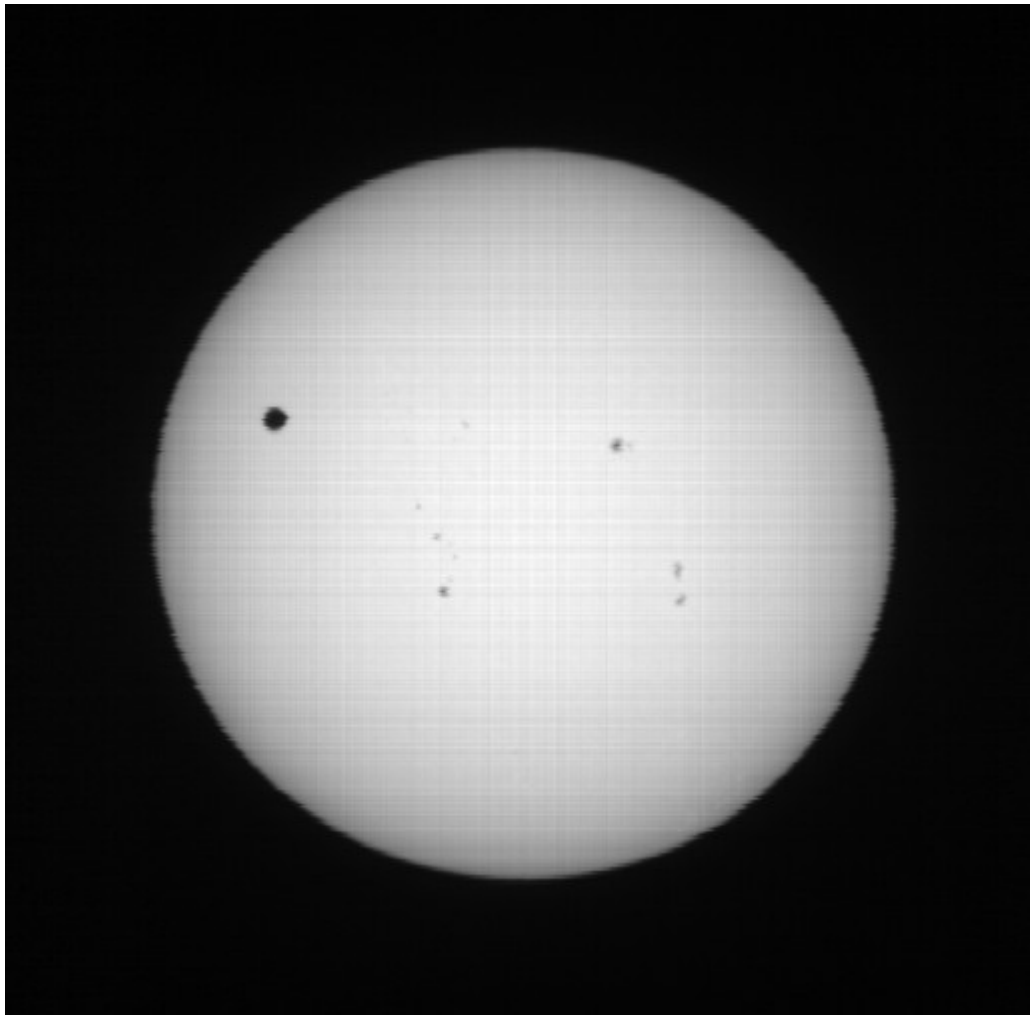
778. (10) nm

998. (10) nm





Venus Transit,
5 June 2012 (max contrast = -.88)



Scientific Justification

Need to understand and remove solar changes from other forms of climate forcing.

Spacecraft measurements of TSI and SSI not imaged.

Our program measures relative changes due to solar activity.

Our photometric indices correlate with TSI with R^2 better than 0.9.

Photometric Indices

Red Images

Photometric Sum

$\Sigma_r = \sum_i (\Delta I/I)\, \Phi_r(\mu)$ [no feature identification]

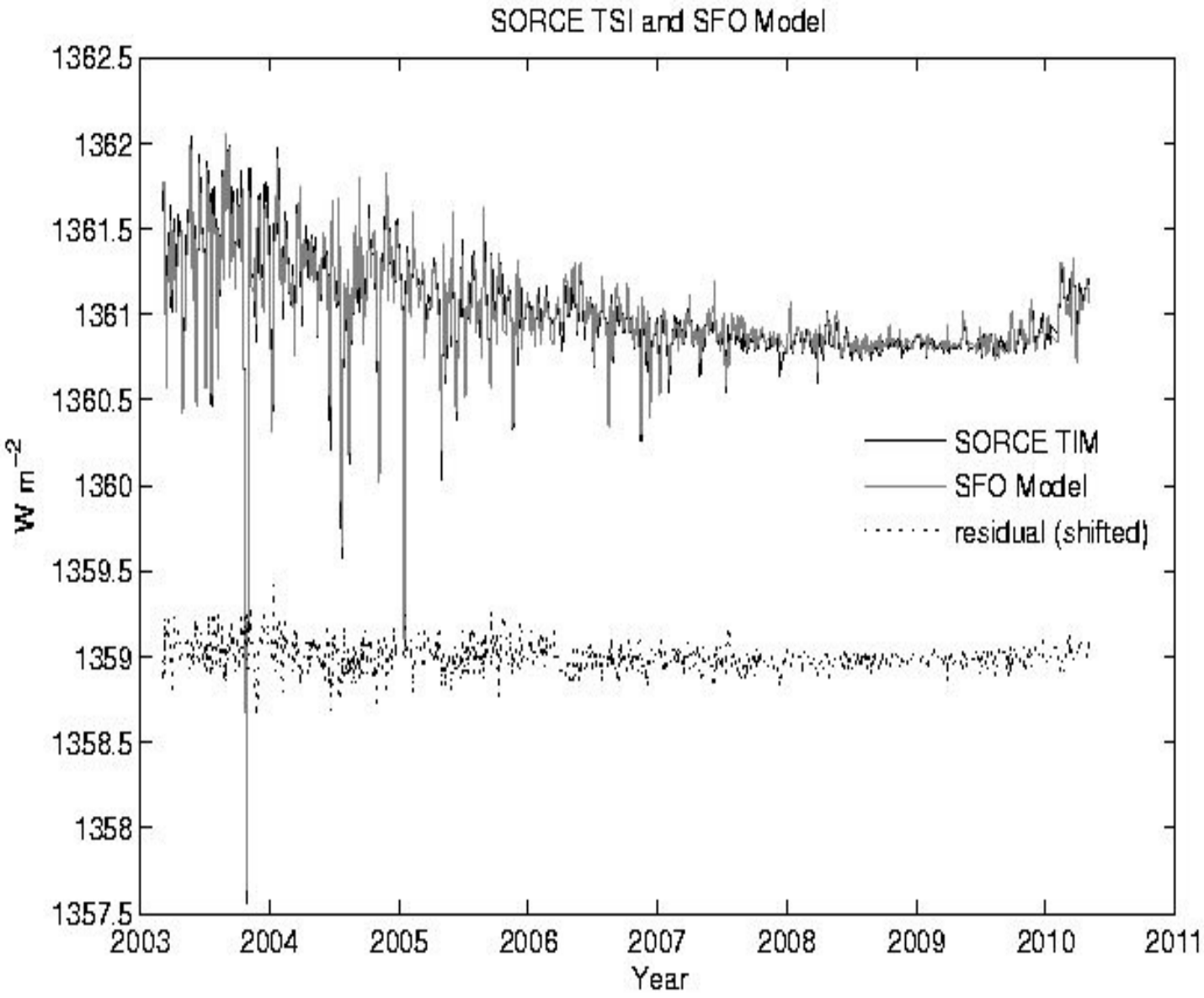
Photometric Sunspot Index (model)

$PSI = C_S \sum A_S\, (3\,\mu + 2)$ [≤ -8.5%, only]

K-line Images

$\Sigma_k = \sum_i (\Delta I/I)\, \Phi_k(\mu)$ [no feature identification]

$PFI = C_p \sum A_f\, (3\mu + 2)(1/\mu - a)$ [≥ 4.8%, only]


SORCE TSI and SFO Model
1362.5
1362
1361.5
1361
1360.5
1360
1359.5
1359
1358.5
1358
1357.5
W m^{-2}
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
SORCE TIM
SFO Model
residual (shifted)

REGRESSION RESULTS

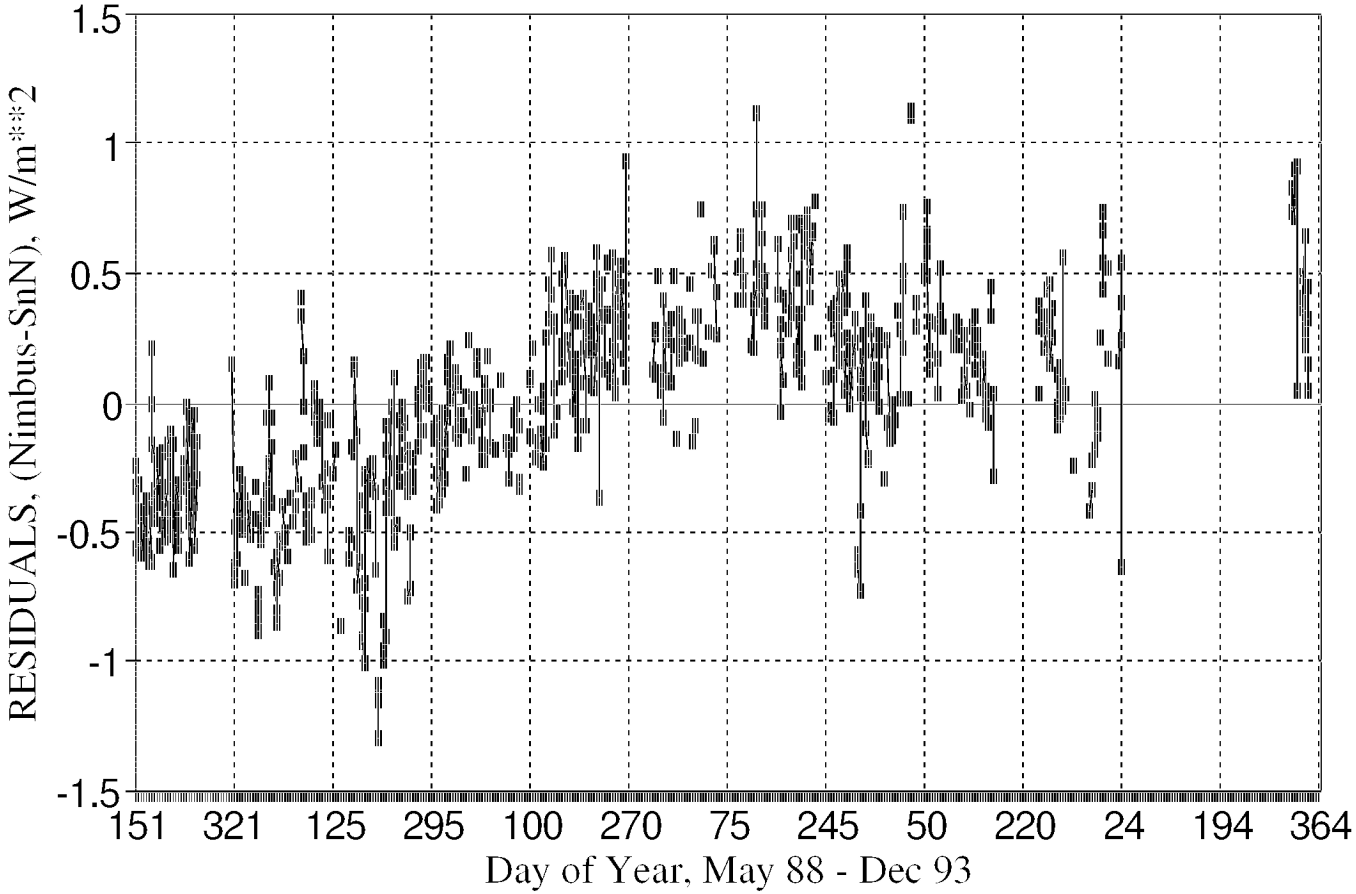
- $S = S_0 + A * \Sigma_r + B * \Sigma_K$
- $S_0 = 1360.81 \pm 0.004$
- $A = 1.025 \pm 0.008$
- $B = 0.1257 \pm 0.001$
- $R^2 = 0.9495$
- $N = 1253$

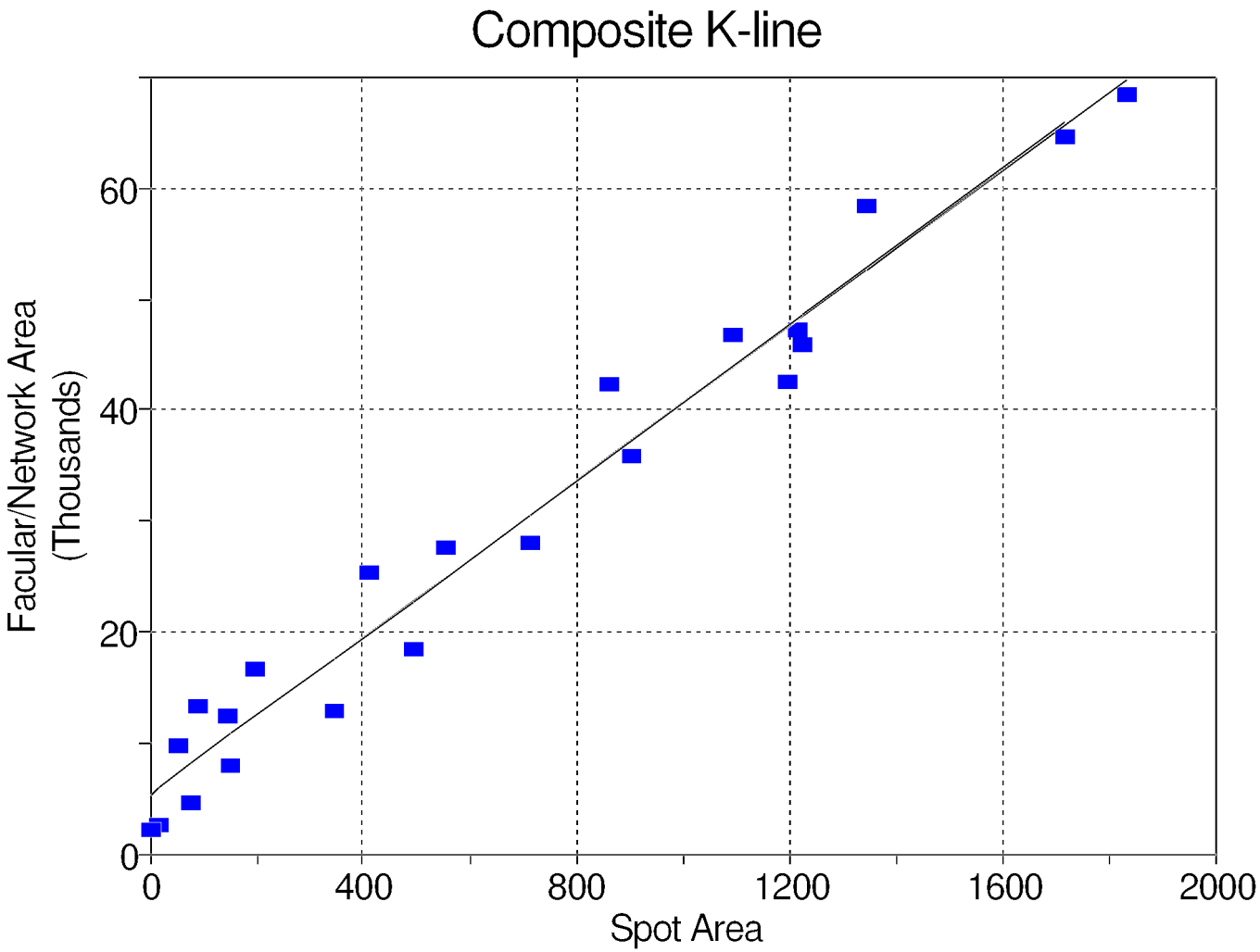
Scientific Just. (cont'd)

- Our data can be used to correct S/C upsets.
- Our data can be used to connect different S/C TSI (having different scale factors).
- Imaged data necessary to understand the sources of TSI and SSI variations.

NIMBUS-7 vs CFDT1 w/NOAA9 DATA

747 Data Points - 1988-93




Composite K-line
Facular/Network Area
(Thousands)
0
20
40
60
0
400
800
1200
1600
2000
Spot Area

Bolometric Contrast

The Bolometric Contrast, α, is the bolometric irradiance deficit of a sunspot as seen from the surface of the Sun, not from the Earth.

A similar term for faculae/ network is not so easy; the facular contrast is a sensitive function of disk position.

Bolometric Contrast, con't.

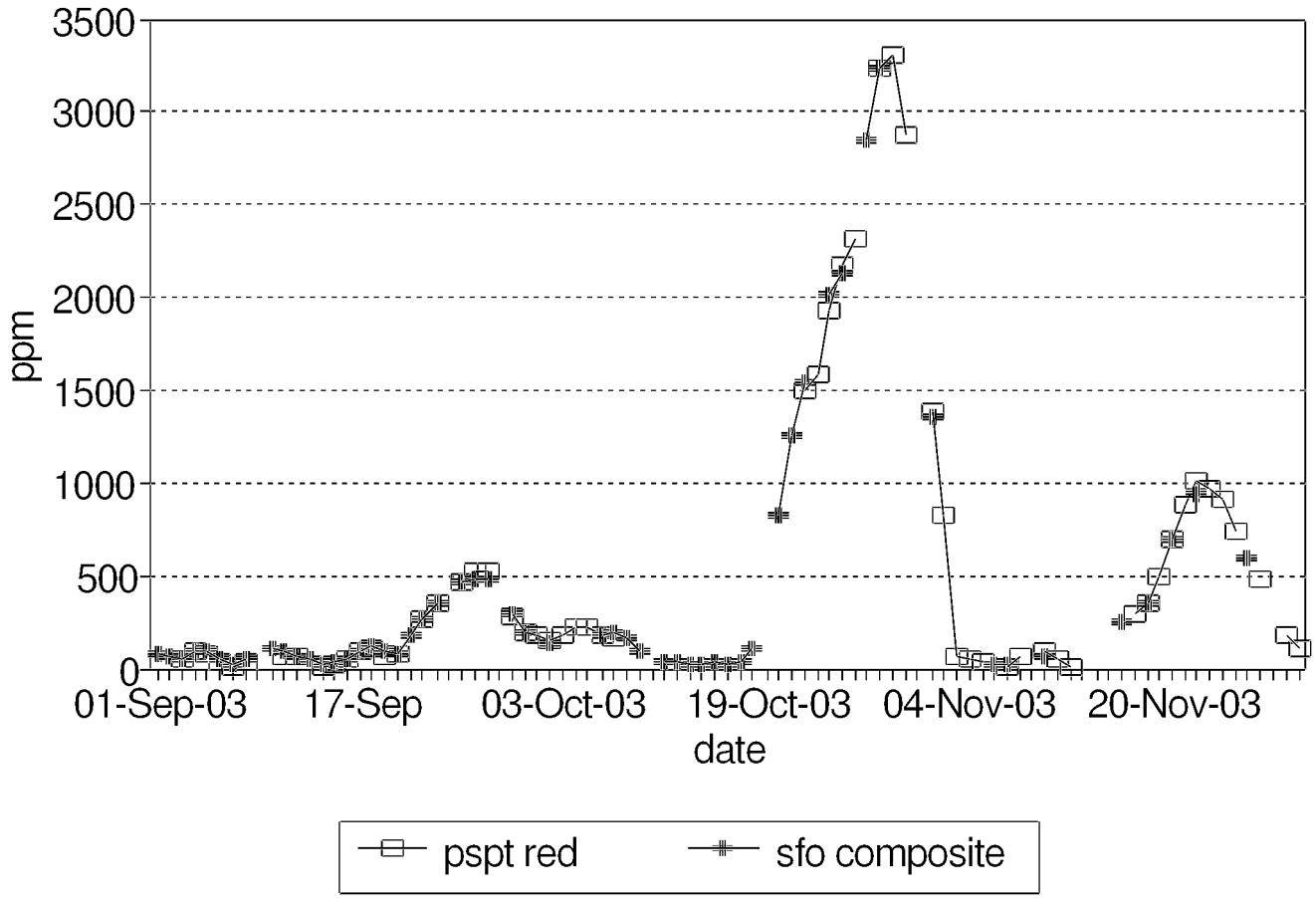
The bolometric contrast, α_{eff}, of a sunspot is the irradiance deficit as seen at the surface of the sun; not from the earth. It is given by

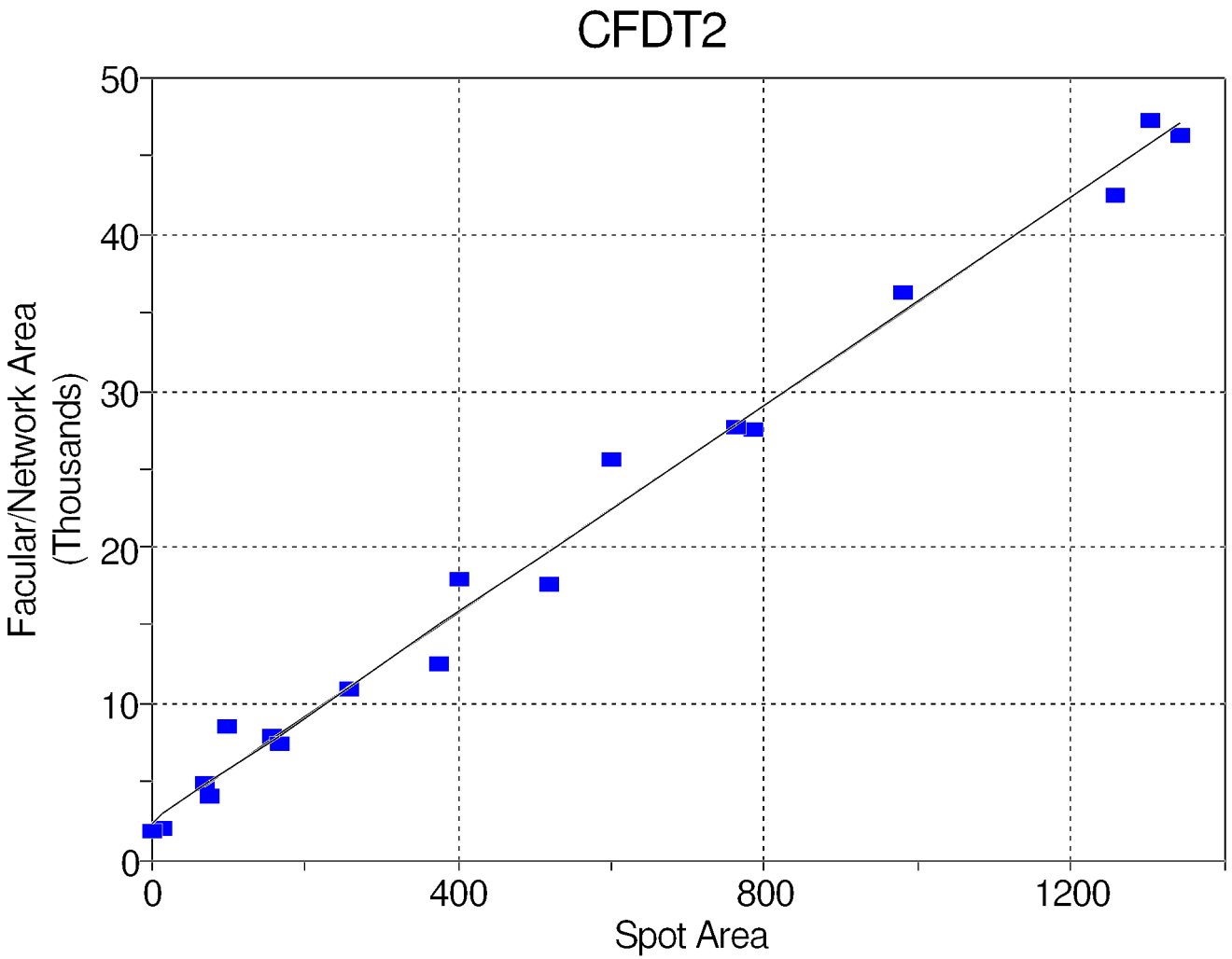
DEF/(2 * PSI)

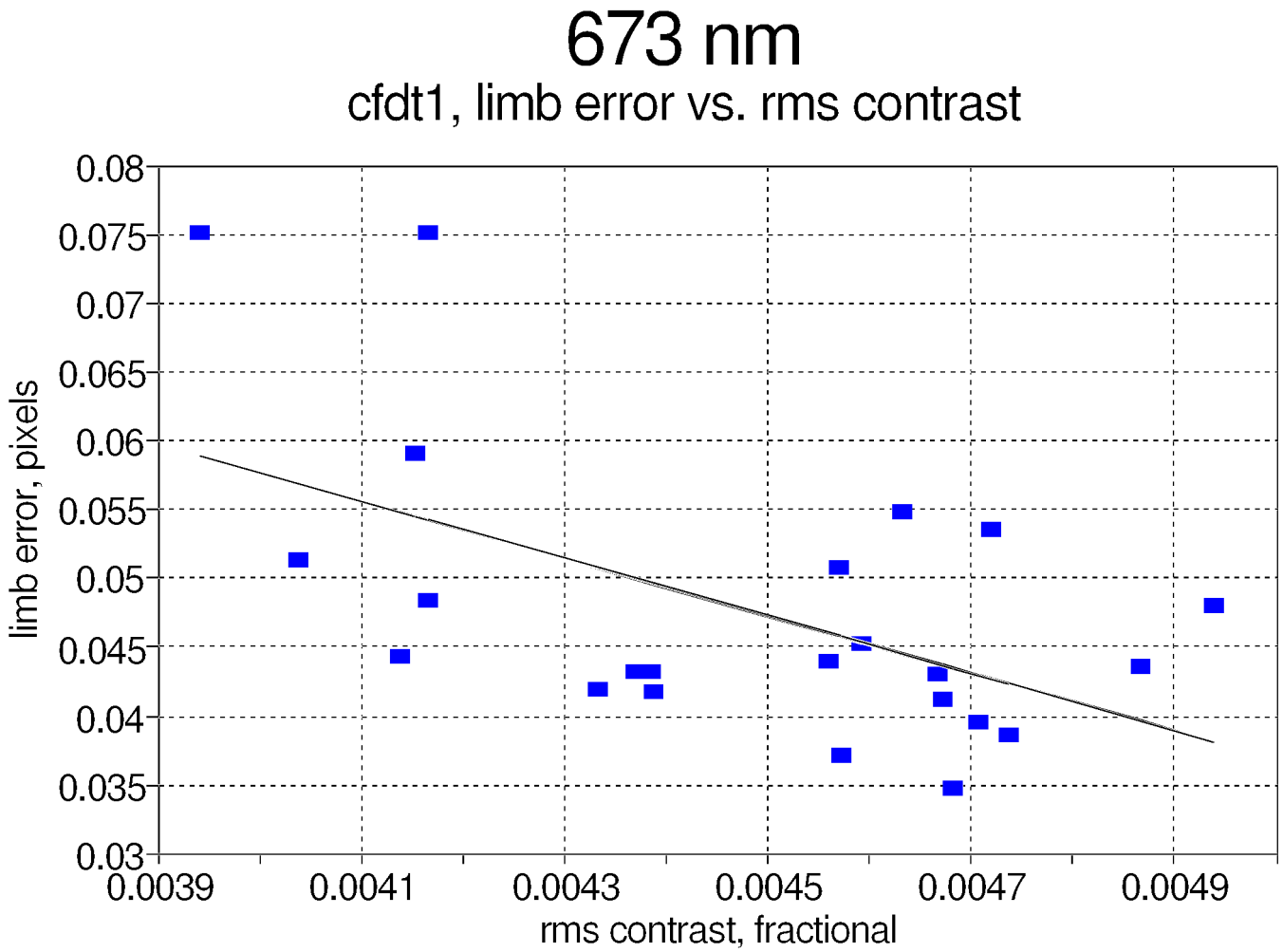
The bolometric contrast, when integrated over the solar sky of a sunspot, gives its luminosity deficit.

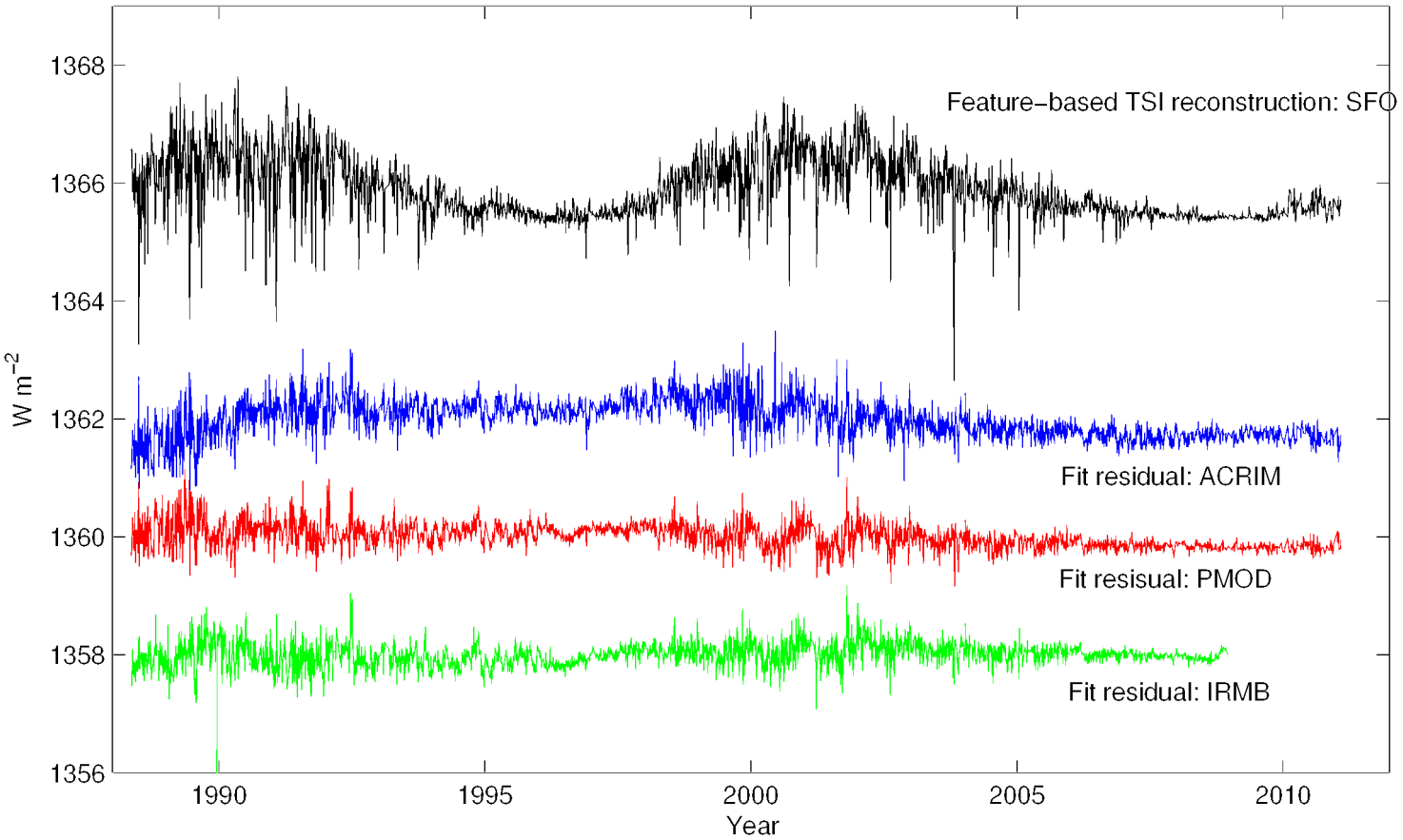
composite deficit, no time correction

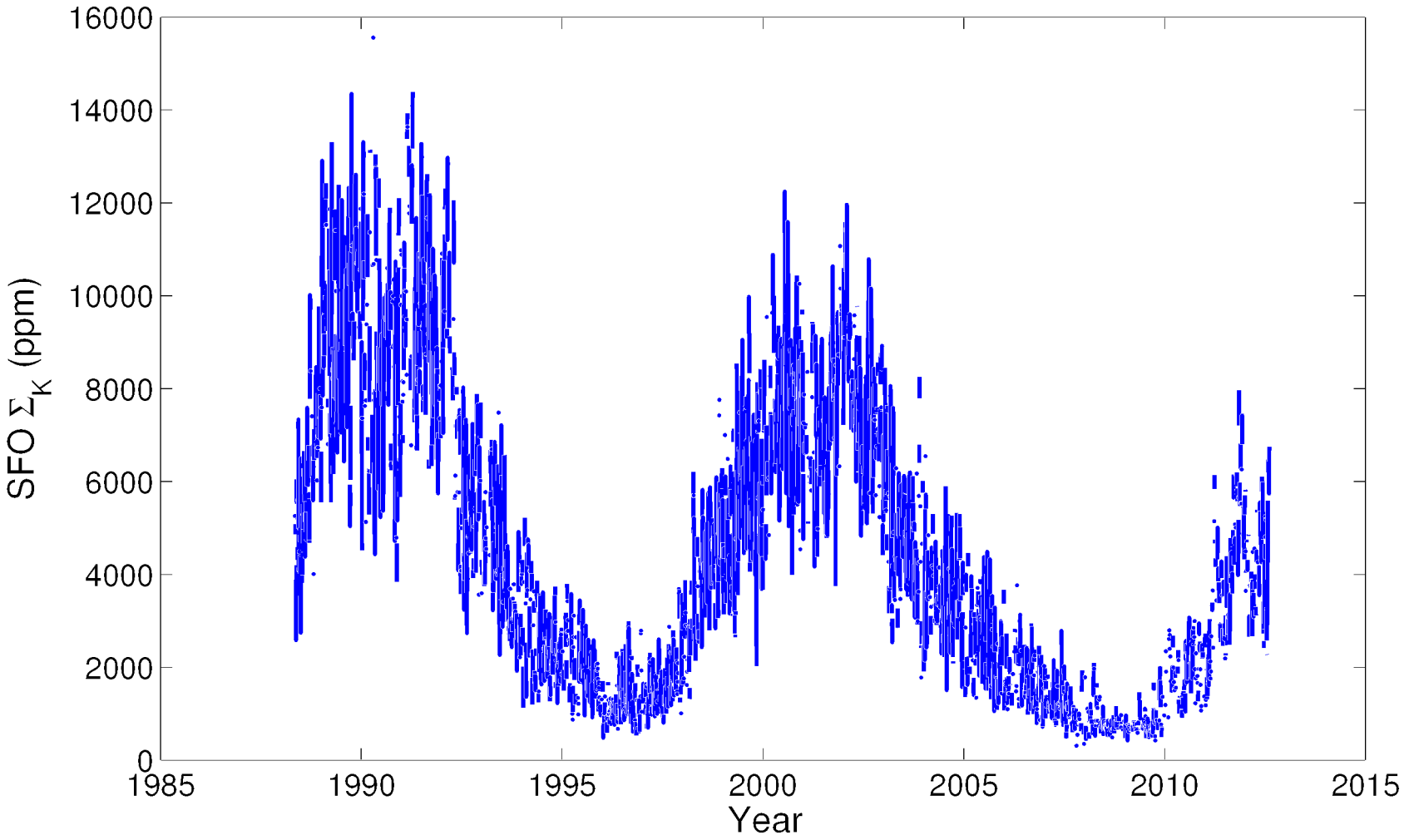
composite using sfo(blue and red)cfdt2

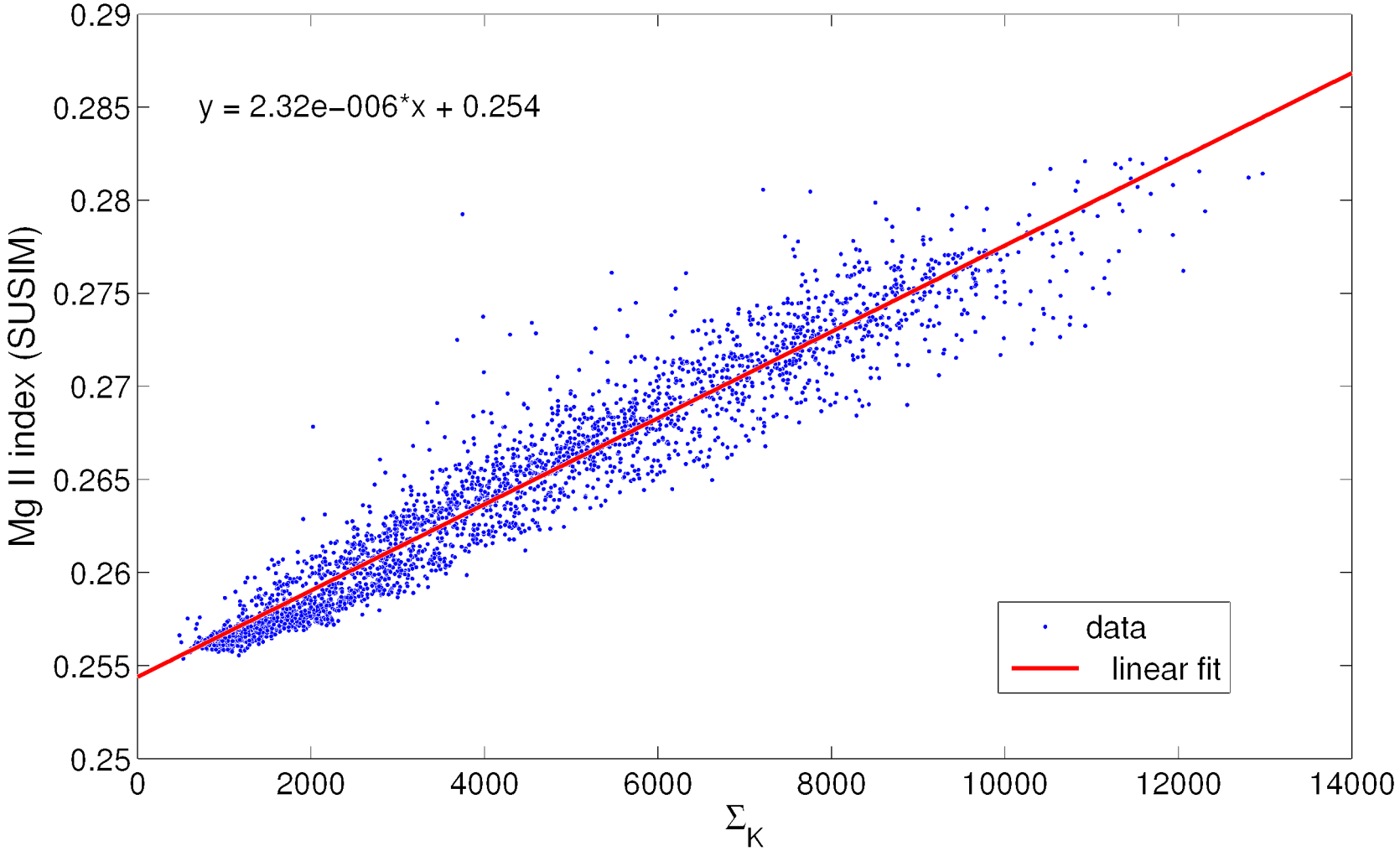


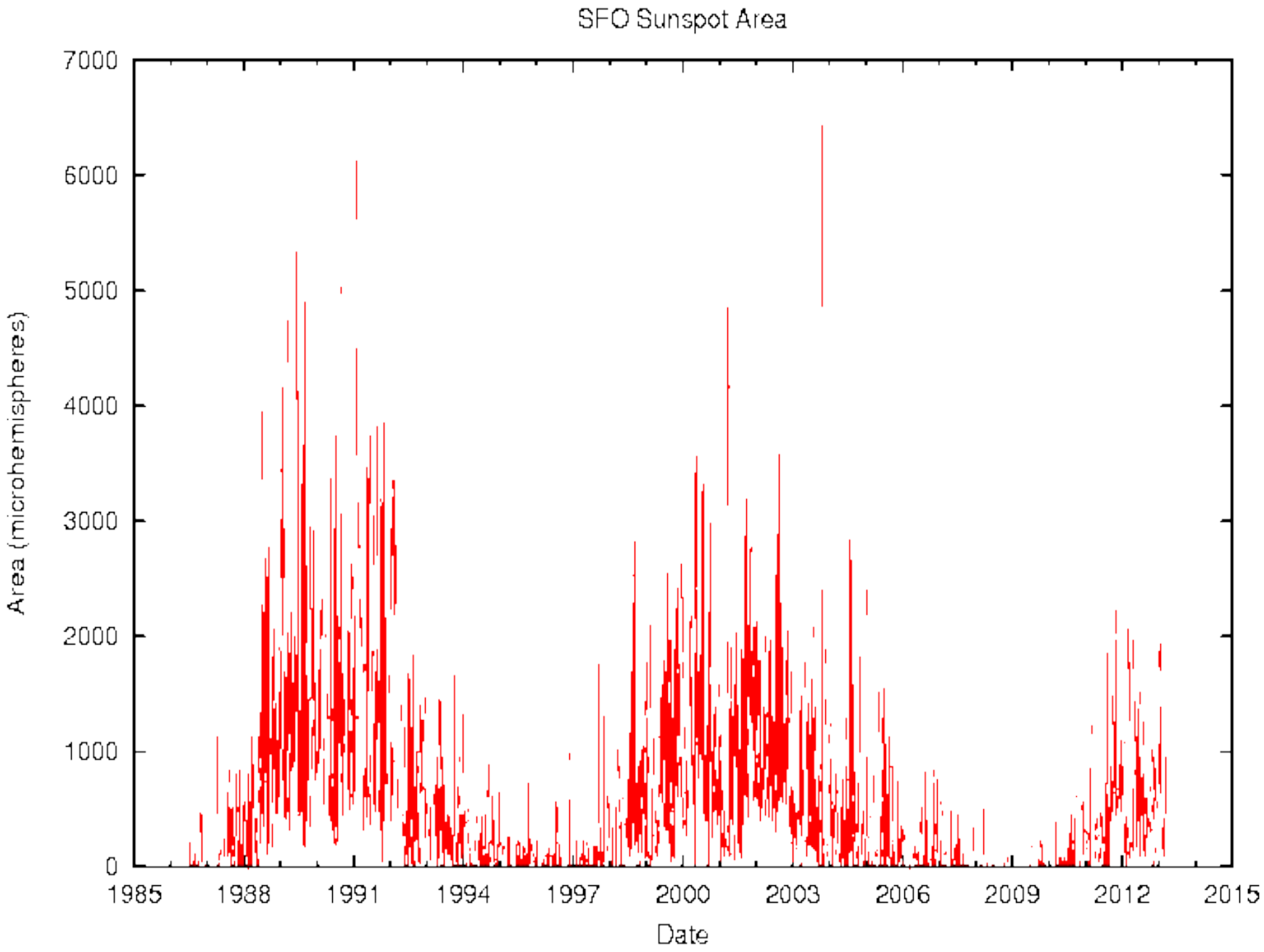

CFDT2
Facular/Network Area
(Thousands)
50
40
30
20
10
0
0
400
800
1200
Spot Area

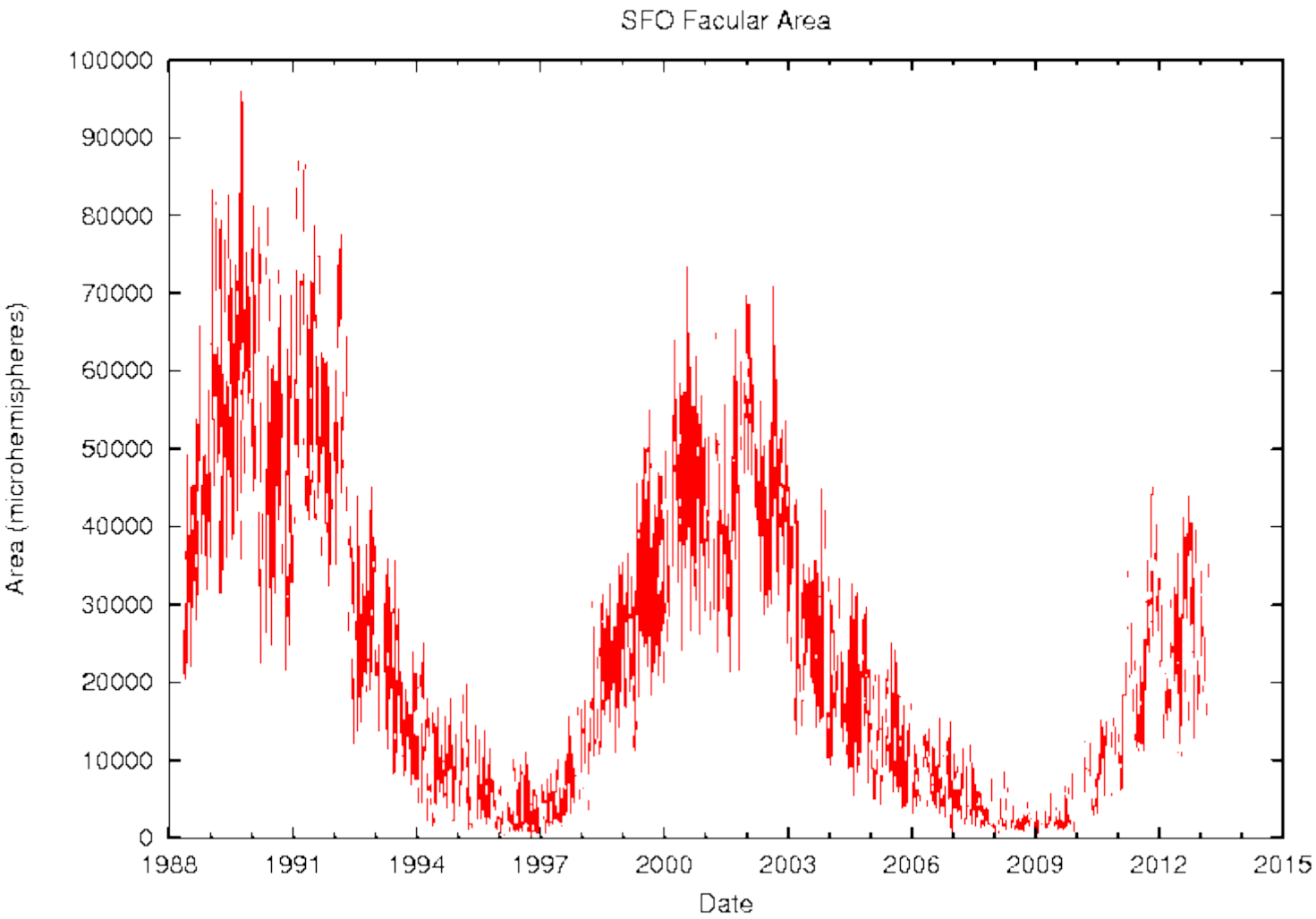

673 nm
cfdt1, limb error vs. rms contrast
limb error, pixels
0.08
0.075
0.07
0.065
0.06
0.055
0.05
0.045
0.04
0.035
0.03
0.0039
0.0041
0.0043
0.0045
0.0047
0.0049
rms contrast, fractional


Feature−based TSI reconstruction: SFO
Fit residual: ACRIM
Fit resisual: PMOD
Fit residual: IRMB
W m^{-2}
1368
1366
1364
1362
1360
1358
1356
1990
1995
2000
2005
2010
Year

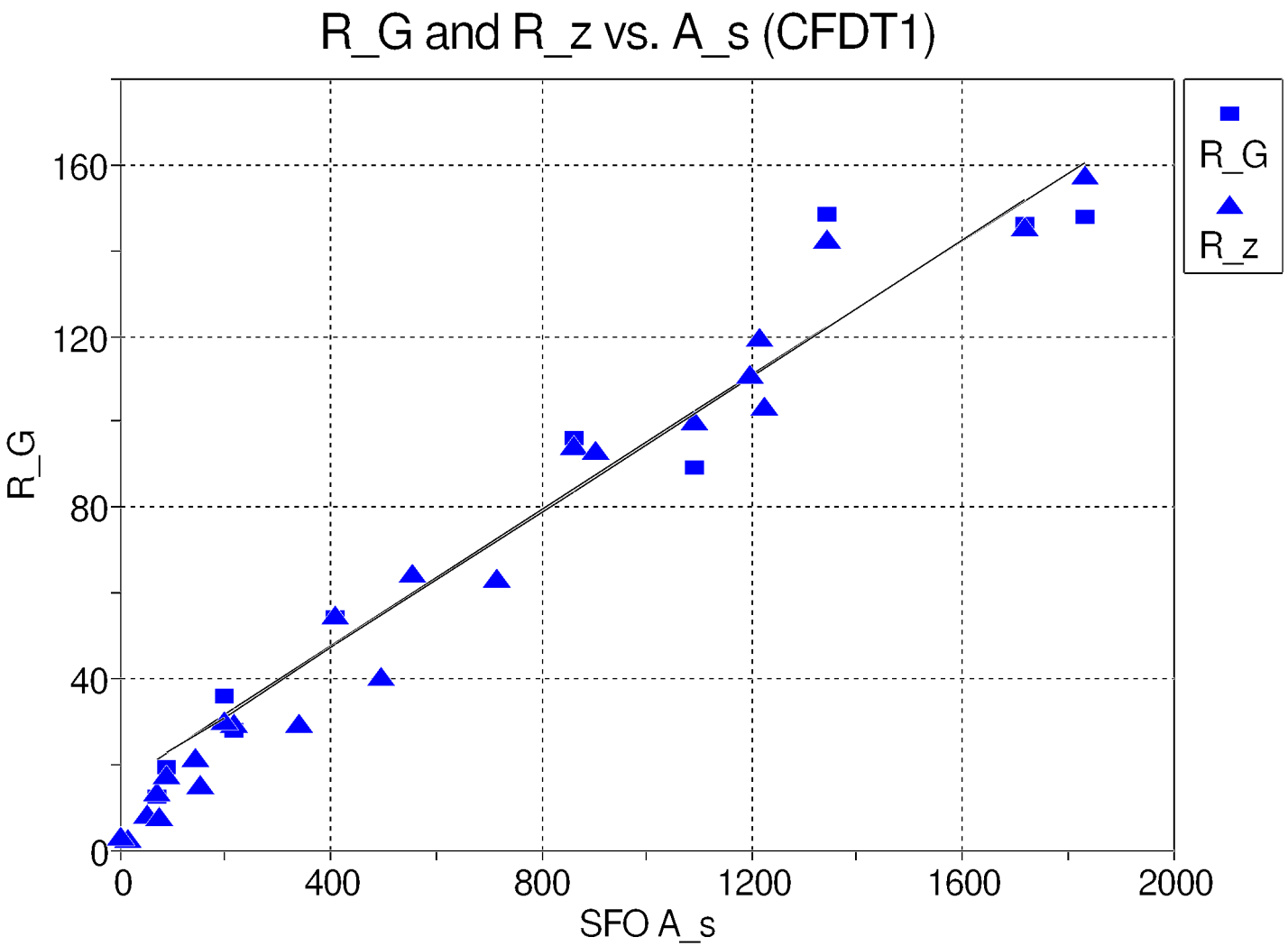

16000
14000
12000
10000
8000
6000
4000
2000
0
SFO Σ_K (ppm)
1985
1990
1995
2000
2005
2010
2015
Year


y = 2.32e−006*x + 0.254
Mg II index (SUSIM)
0.29
0.285
0.28
0.275
0.27
0.265
0.26
0.255
0.25
0
2000
4000
6000
8000
10000
12000
14000
Σ_K
data
linear fit

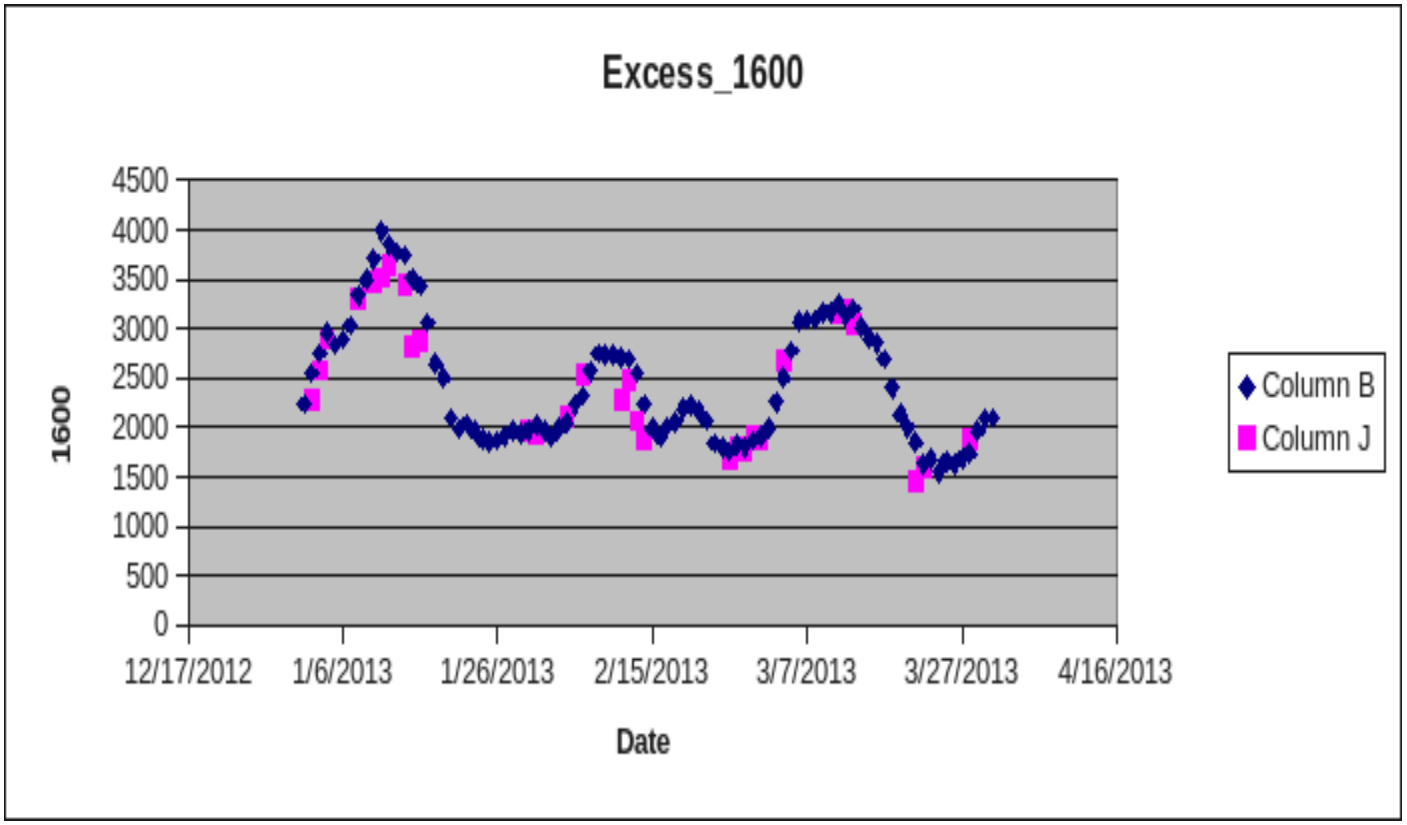

SFO Sunspot Area
Area (microhemispheres)
7000
6000
5000
4000
3000
2000
1000
0
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
Date


SFO Facular Area
Area (microhemispheres)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
Date

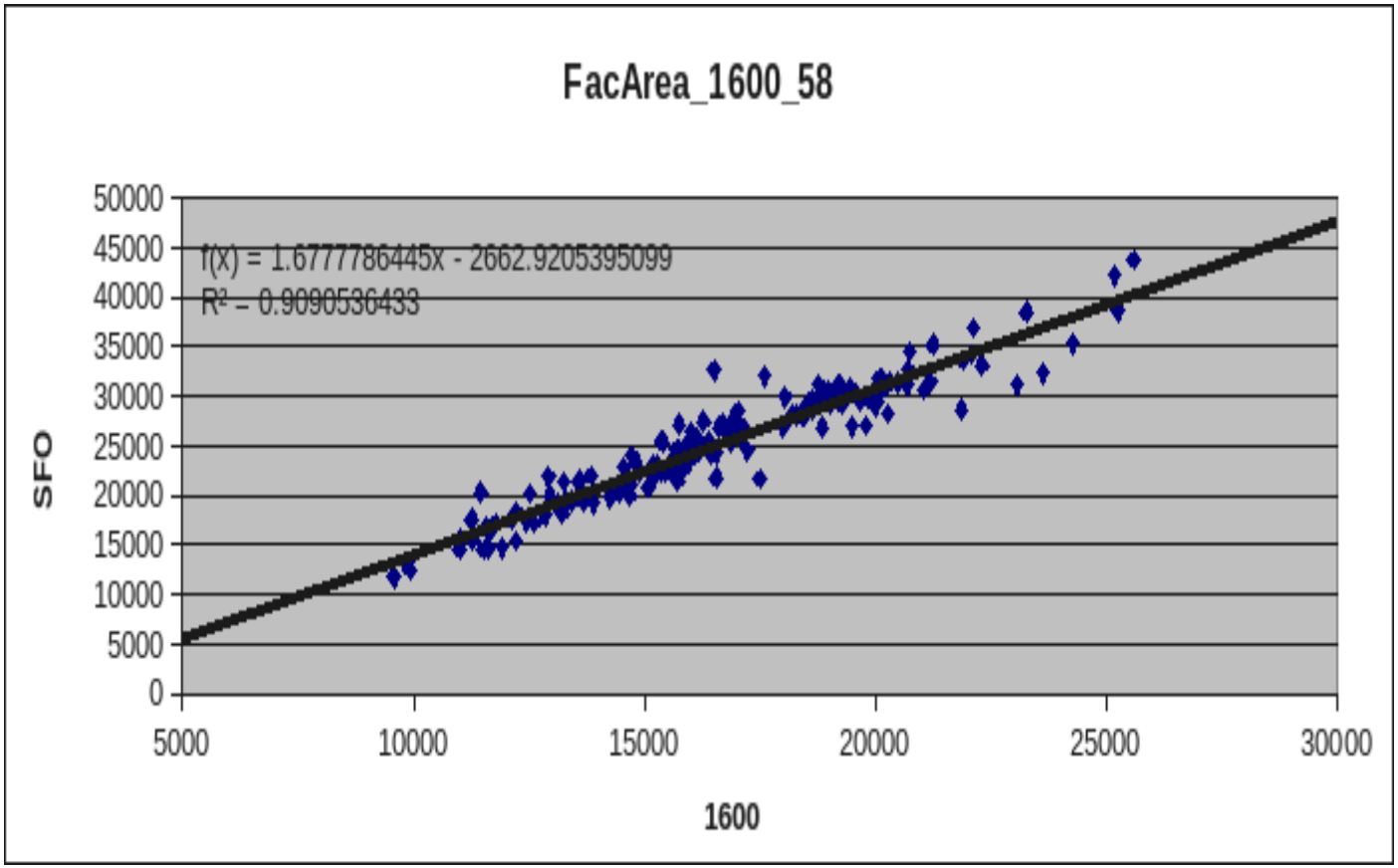
Annual Means



Facular Excess, SFO & SDO



Facular Area, SFO & SDO



Acknowledgements

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- Over the years, many student observers have contributed to data collection and data analysis.
- The work using SDO data was carried out by Kemal Yassin and Debi P. Choudhary.